Remarks

Claims 1-3 and 5-28 are pending in this application.

Claims 1-3, 5-8, 11-13, 16-21, 25-27 and 28 are rejected under 35 U.S.C. 102(a) as being anticipated by Tatah et al, (US Patent 6,347,171) which is a reference submitted by the applicant.

Claims 9-10, 14-15, 22-23 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tatah et al. (U.S. Patent 6,347,171) as applied to claim 1.

With regard to the rejection of claim 1 under 35 U.S.C 102(a), the Examiner notes that Tateh et al. disclose a method for forming a diffraction grating in an optical fiber comprising:

Providing an optical waveguide 116 [fig. 1];

Disposing a mask 110 [diffractive optical element, col 2 line 16]

Providing electromagnetic radiation having a pulse duration less than 500 picoseconds [102, ultrashort pulse laser as shown in abstract].

The Examiner further points out that the laser of Tatah et al. is capable of generating light pulses that last only a few femtoseconds, which is less than or is equal to 500 picoseconds as claimed in claim 1.

It is further noted in the Office Action that the claimed limitations regarding intensity are considered to be inherently done by Tatah et al. to maintain and properly operate the optical system.

With regard to the rejection of claim 2, it is said in the Office Action that Tatah et al. teach at column 2, lines 23-28 that the grating can be done in the cladding of the optical fiber.

Considering claim 3, the Examiner states that it is clear that the ultrashort pulse laser is generating a few femtoseconds, which is less than 100 picoseconds. The Office Action further states that Tatah et al. show in Fig. 1 and Fig. 2 that the distance between the mask and the fiber <u>is close enough</u> so that the group velocity walk-off results in pure 2-beam interference.

In order to expedite allowance of this application the applicant has cancelled claim 1, without prejudice.

The applicant respectfully disagrees with the Examiner with regard to the patentability of claim 3.

The Examiner's comment that the distance between the mask and the fiber is close enough so as to result in pure two beam interference is an interesting one since Tatah et al. do not teach an embodiment wherein the distance between the fiber and mask is far enough away to result in pure two-beam interference.

It is acknowledged that Tatah et al. teach an arrangement wherein a fiber is placed a distance away from a mask and wherein a pulse of a few femtoseconds can be utilized to write a grating by interfering within the fiber sub-beams of light received from the grating.

However, Tatah et al. do not teach a method of writing wherein two beams interfere as a result of arranging a waveguide and a mask a "predetermined" distance "d" such that for a given pulse duration only two pure-beam interference occurs.

Fig. 1 of Tatah et al., is the only teaching where guidance is provided with respect to the distance between the fiber and the mask; and shows the fiber to be very close to the mask. In fact the fiber is much less than a fiber diameter away from the mask. A standard optical fiber is 125 microns in diameter. In the Tatah's figure the spacing between the fiber and the grating seems even to be less than the thickness of the cladding of the fiber. Simply put, Tatah does not show an embodiment where pure two-beam interference would occur as a function of walk off of the higher orders. If Tatah's phase mask was not designed to suppress the zero and higher order modes, they would most certainly interfere within the waveguide. It should also be noted, that in practice, complete suppression is not attained by a conventional mask designed to suppress the higher order modes.

The applicant has used the calculations in paragraph 70 of the instant application to determine if the embodiments disclosed by Tatah et al. in column 5, lines 51-57, result in pure two-beam interference due to group velocity walk-off.

Tatah et al. disclose a 1.55 micron pitch mask, an 0.8 micron laser wavelength, and a 150 fs pulsed laser. The minimum distance "d " where the +/- 1 orders walk-off the zero order occurs at about 313.5 microns, which is larger than two standard fiber diameters, or about 2 x125 microns. This would mean that the surface of a standard fiber would need to be placed 250 microns or 2 fiber diameters away from the phase mask so that a grating was written into the core 62.5 microns into the fiber.

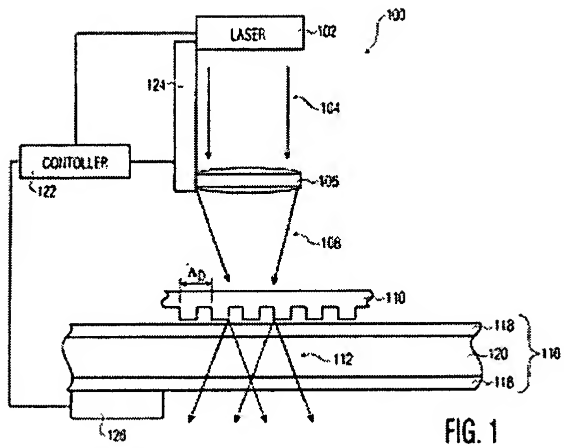

FIG. 1

Claim 3 of the instant invention has been amended to more clearly define the invention and is written below in independent form including the limitations of claim 1.

In the cited Tatah et al patent, col. 3, the following text is found:

"FIG. 2 illustrates the intersection of a first ultrashort laser pulse 202 and a second ultrashort laser pulse 204 generated by the diffractive optical element 110. In this exemplary embodiment, the first and second ultrashort laser pulses 202, 204 represent the -1 and +1 order beams, respectively, diffracted by the diffractive optical element 110. As known to those skilled in the art, the diffractive optical element 110 may be designed to suppress higher order diffractions."

Tatah et al. specifically disclose and illustrate interfering the +1 and -1 order pulses with one another in the waveguide core so as to write a grating in the core of a fiber.

There is further teaching by Tatah et al. that one skilled in the art would know that the diffractive optical element can be <u>designed so as to suppress the higher orders of diffraction</u>.

In contrast, the instant invention teaches and defines in amended claim 3, above: disposing and orienting the mask adjacent to the at least partially transmissive material at a distance "d" such that group velocity walk-off results in pure two-beam interference within the at least partially transmissive or absorbing material when irradiated with a pulse of light of less than or equal to 100 picoseconds, wherein the distance "d" is chosen such that the difference in times of arrival of the order pairs due to group

velocity walk-off results in the pure two-beam interference pattern of sub-beams of said pulse of light that have passed through or reflected off of the mask.

The instant invention provides a mask wherein different ordered pairs are generated by the mask rather than attempting to suppress unwanted orders thereby attempting to obviate their interference by eliminating them as Tatah et al. suggest.

Thus, instead of having to design a mask so as to suppress the zeroth mode, or higher order modes, this invention allows their generation by the mask and utilizes the temporal and spatial relationship between arrival of pairs of pulses at a predetermined location so at to ensure that the +1,-1 and +n,-n, where n=2.... ∞, do not arrive at the at least partially transmissive of absorbing material at the same time. Due to the difference in angle, at which different +- orders of pulses exit the phase mask, they reach the waveguide at different times. If the waveguide is a sufficient distance "d" from the mask, only one pulse pair, i.e. +1 -1, will arrive and interfere within the at least partially transmissive or absorbing material, without other orders interfering at the same time.

It is clear that by placing the waveguide against the phase mask that all of the diffracted orders will impinge upon the waveguide at the same time and interfere with each other; after considering this, the applicant has discovered , that there is a location (at at least a distance "d") wherein for example the fiber can be disposed away from the mask where only the + 1 and – 1 orders will interfere within material and have sufficient intensity to cause a refractive index change.

Designing a mask that will null or suppress orders other than the +1 and -1 is very difficult to achieve. In most instances there will always be some energy in those suppressed orders reaching the target that is to be irradiated.

However, by finding the "sweet-spot" in which to locate the fiber or waveguide, that is, the region at at least a distance "d" beyond which group velocity walk-off results in pure beam interference, is highly advantageous.

Instead of using a brute force approach as is taught by Tatah et al., the effort and expense of attempting to design a mask that will suppress unwanted modes is obviated. By relying on positioning the waveguide to be written or material to be irradiated in such a manner as to have only one pair interfere at an instant in time, provides an elegant solution not apparently contemplated by Tatah et al.

With regard to the Examiner's rejection of claim 9, the Examiner states that it would have been obvious to modify Tatah et al. to include an external jacket layer for protecting from the outside environment as it would be clear that it would improve the device.

Applicant would like to point out that commercially available optical fiber typically has a core of a first refractive index n1 and cladding with a different refractive index n2, wherein n1>n2. Commercially available optical fiber also has a protective jacket to protect the fiber from damage. This protective jacket is not an "optical" part of the waveguide; it is not a cladding which controls the propagation of light; it merely protects the fiber from scratches and breakage, humidity and other harsh environmental affects. The jacket is not the applicant's invention as it is well known. Notwithstanding, writing the core or cladding through the jacket with IR pulses is novel and inventive. It is common practice to remove the jacket in order to write a grating into the core of an optical fiber. By writing through the jacket with IR pulses time and expense are saved; and recoating the fiber where the jacket would have been removed is not required. This is a significant manufacturing advantage.

Claim 10 has been rejected and the Examiner states that it is clear that the external jacket layer is an extra cladding layer.

It appears that there is some misunderstanding regarding the cladding layer and the difference between a cladding layer and a jacket layer. An extra cladding layer is a third region of a waveguide, i.e. there is a waveguide with a core, first cladding having a refractive index n2, second cladding having a refractive index n3, wherein the second cladding forms an extra cladding layer. As was pointed out regarding claim 9, the jacket is not the cladding, it is a protective layer made of a different material than the waveguide core and cladding layers.

Claim 10 now dependent upon amended claims 2 and 3 is believed to be patentable.

With regard to claims 14 and 15, the Examiner states that Tatah et al teach in col 5, lines 40-63, that the method of making a grating can be utilized on any optical element; therefore it would have been obvious to modify the Tatah et al device to be utilized in the tapered optical fiber and fused biconic tapered coupler for the purpose of higher coupling efficiency of the device. The Examiner further states that Official notice is taken that tapered optical fiber and fused biconic tapered couplers are old.

After reading the specification, the applicant could not find any passage in Tatah et al. wherein he teaches that the method of making a grating can be utilized in any optical element. The passage found which refers to variants appears to be one which states:

"The present invention is not limited to forming diffraction gratings in optical fibers. For example, the teachings of the present invention may be used to form diffraction gratings in other transparent materials such as bulk glass."

With regard to optical couplers, the Applicant has not invented the tapered coupler or the biconic tapered coupler. However what the applicant has done is realize a method in which precise gratings can be written into thin waveguides such as biconic tapered couplers by using pure two beam interference. It is otherwise very difficult to precisely write these miniature optical structures. Furthermore, a new useful and inventive device is realized by writing one or more gratings in a tapered waveguide. For example, these can be used in sensing applications. Tatah et al. have not suggested such a class of optical devices written in this manner. The applicant would like to point out that because Tatah et al. have suggested writing other materials does not preclude the applicant from having invented a novel and inventive structure and method of writing such a structure.

It is believed that all claims dependent on claim 3 of the instant patent application are both novel and inventive. Claim 3 defines a novel and inventive method and claims dependent thereon add yet further invention.

Claim 9 as amended is believed to be patentable. Heretofore, no one has suggested writing a spatial intensity modulation pattern in an optical fiber with IR through a protective jacket forming a sheath around the optical fiber.

Claims 20, 21 and 28 have been cancelled.

In view of the foregoing remarks and amendments to the claims, it is respectfully submitted that the instant application is now in condition for allowance.

Early and favorable reconsideration of the Examiner's objections would be appreciated.

Should the Examiner determine any minor informalities that need to be addressed, she is encouraged to contact the undersigned attorney at 613-523-3784.

The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account No: 50-2810.

Please associate this application with Customer No: 24949.

Respectfully,

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